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ABSTRACT

This study documents the type of support and professional growth science teachers gained as they implemented technologies from summer institutes. Teachers and staff maintained communication after the program through a telecommunications network. This study involved 91 high school science teachers from across the country who participated in an NSF funded science program. A two week institute introduced content about "patterns in nature," an interdisciplinary approach to science, with an emphasis on various technologies: computer simulations, data collection and analysis software, alternative assessment programs (Audet, et al., 1996); and understanding the role of telecommunications in the teaching of science. Teachers interacted with program staff and fellow participants prior to and following the workshop through a commercial telecommunications network. Teachers most frequently initiated topics relating to technology. Observations from teacher dialogue indicated that teachers required individual staff support through email, but also engaged in sharing technology resources and classroom experiences with colleagues and staff, and reflected about their teaching in public areas of the network. This telecommunications network created a professional context comparable to collegial environments and other current models of professional development. (Author)

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Telecommunications as a Context for Supporting Science Teachers

Implementing Technology in the Classroom

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Abstract

This study documents the type of support and professional growth science teachers gained as they implemented technologies from summer institutes. Teachers and staff maintained communication after the program through a telecommunications network. This study involved 91 high school science teachers from across the country who participated in an NSF funded science program. A two week institute introduced content about "patterns in nature," an interdisciplinary approach to science, with an emphasis on various technologies: computer simulations, data collection and analysis software, alternative assessment programs (Audet, *et al.*, 1996); and understanding the role of telecommunications in the teaching of science. Teachers interacted with program staff and fellow participants prior to and following the workshop through a commercial telecommunications network. Teachers most frequently initiated topics relating to technology. Observations from teacher dialogue indicated that teachers required individual staff support through email but also engaged in sharing technology resources and classroom experiences with colleagues and staff, and reflected about their teaching in public areas of the network. This telecommunications network created a professional context comparable to collegial environments and other current models of professional development.

Introduction

Research indicates that successful implementation of technology, like microcomputers, depends on several factors, such as the quality of training activities, support and feedback after a training program, teacher feedback about their experiences implementing projects, and clear communication about how technology can improve science teaching (Ellis, 1990; Weller, 1997). The extent to which professional growth occurs depends on the amount and quality of support provided after a teacher in-service program (Guskey, 1989; Sparks & Loucks-Horsley, 1983; Mevarech, 1995; Radford, 1998). Teachers require a support system that will meet their needs while they implement new materials. A collegial environment provides the ideal setting for a support system within the working environment. Such collaborative environments help teachers establish relationships based on trust and reflective dialogue (Fullan, 1985; McLaughlin & Talbert, 1993) and develop an understanding about the changes they experience while they explore new practices.

The technology of telecommunications has the power to overcome geographic barriers and time constraints which limit the effectiveness of professional development programs (Lieberman, 1990; Gal, 1993; Caggiano, Audet & Abegg, 1996; Caggiano & Abegg, 1998). Teacher networks are designed for various activities, and those networks associated with professional development programs for teachers have been able to support collaboration of practicing teachers (Kimmel, Kerr, & O'Shea, 1988; Collis, 1992; Brush, Knapczyk & Hubbard, 1993; Honey & Henriquez, 1993), and promote teachers sharing curriculum materials (Dempsey, 1985; Walker, 1987; Mann, 1989; Broholm, 1993). The goal of this research is to examine how telecommunications can

support secondary science teachers who learned and practiced using different types of educational technologies at an in-service program.

Design and Methods

The research design is a modified case study of multiple groups of participants interacting in a telecommunications network following a summer institute. This framework is shown in Figure 1. This design provides a practical approach for exploring how people interact in an electronic network.

Analysis of post institute support included collecting and coding participant dialogue from the communication structures in the network (see Figure 1). Dialogue was analyzed from participants from first and second year interactions in the network to examine patterns of growth over time. The groups of teachers were compared to validate the patterns of dialogue observed in this community.

The goals of the summer program were: 1) to introduce and prepare high school science teachers to use materials developed by projects funded by the NSF Applications of Advanced Technology Program of visual interactive computer models of physical systems; 2) to prepare science teachers for new roles as mentors in a cooperative learning classroom environment in which students act as research workers, learning through hands-on activities, and laboratory experiments; and 3) to introduce teachers to alternative assessment tools requiring the use of technology, such as computer journals (learning logs) and concept mapping.

Procedures

The primary data sources were on-line communications offered through the commercial network, America OnLine (AOL). Data included participant and staff dialogue from three sources: email messages, postings in bulletin board messages, and discussions in on-line conferences, as shown in Figure 1. The dialogues from these communication structures were coded and compared to determine whether or not patterns of activity were exclusive to certain communication structures in the community. Triangulation among the groups of participants and data sources ensured validity in the patterns of dialogue that emerged over time. Participant surveys and program application materials served as secondary sources of data which were used to support observations from the community.

Email messages were collected daily at the staff address. Messages were archived into folders and categorized by month. Bulletin board postings were collected biweekly and archived by section and month. On-line conference discussions were monitored and saved by date.

Data from these sources were categorized into years; for example, a first-year participant in the community would interact for a year, from the June before she or he attended the summer program until one year after they began participating on line. The data for each year were sub-categorized by months: Summer (June-August), Fall (September - November), Winter (December - February), and Spring (March - May). This type of organization of data allowed for a seasonal analysis of data for convenience of analysis and to look for more specific patterns within each year.

The data files were coded to determine the types of dialogue mentioned each month by groups of participants. Then these files and the codes identified were put into HyperResearch®, a qualitative, coding and theory-building tool which uses Boolean logic to compare lines of dialogue. The program was used to sort data to highlight and document categories of discourse frequently mentioned. For example, comments regarding equipment or activities pertaining to summer program computer hardware, software, visual models, or data collection tools were categorized as Technology.

Individuals also wrote about an activity or behavior that they had experienced, an example of reflecting on an experience. The messages from all communication structures were further analyzed to determine whether and how participants reflected on their practice based on research by Van Manen (1977) who discovered that teachers reflect on technical management issues, practical actions in the classroom, and ethical or moral aspects of curriculum knowledge. To estimate coding reliability two research associates coded randomly selected entries and achieved an interrater agreement level of 75%. The categories of reflective messages were compared using HyperResearch® to determine how often reflective discourse occurred. Secondary data sources included surveys from participants.

Setting

Staff

The staff consisted of a team of scientists, science educators, and teachers. This group was responsible for organizing and maintaining the summer program as well as communicating through the network to provide further support for participants. Scientists, teachers, and science

educators participated in instructional activities with participants. Following the summer program, two staff members were selected as coordinators responsible for using telecommunications to facilitate correspondence among participants and staff. Staff members interacted daily, coordinating activities and evaluating the network through email.

Participants

Ninety one secondary science teachers participated in this telecommunications experience for over two years. Tables 1 and 2 provide a profile of these participants. During the first year there were 32 science participants and 59 the second year. Science teaching expertise varied across the disciplines as shown in Table 2.

Most participants indicated they used computers. However, only 25% of the 1994 participants reported using the computer in the classroom while more than half the 1995 participants reported using computers in the classroom. Participants who used computers with students also reported using tutorial programs, encyclopedias, graphics, multimedia, or spreadsheets. A few participants, who had five to eleven years of teaching experience, claimed to have little skill with the computer.

The Institute

The two week summer institute began with an information session and social gathering the evening before the formal instruction began. Books, instructional materials, and schedules for the summer program were distributed at this session. The actual summer program consisted of 10 work days, from 8:30 a.m. to 5 p.m. Participants had access to computers for project work, personal use, or email before and after the work day.

Table 1
Profile of Participants

Year	Gender		Level	
	M	F	HS	MS
1994	19	13	32	0
1995	30	29	52	7

Note. Teaching experience varied from 1-30 years.

Table 2**Participant Teaching Areas**

Year	Biology	Chemistry	Earth Science	Physics	Total Disciplines
1994	21	5	4	8	38
1995	28	18	5	24	76

Note. Participants taught in various science subject areas, often in more than one discipline.

Participants met at the same lab facility and worked in pre-assigned interdisciplinary groups, consisting of three participants at a computer station. During the first week of the program staff presented materials in a cooperative learning environment. One objective for the program was demonstrating how to establish a learning environment in which students could act as researchers. Participants were introduced to an alternative teaching role, that of mentor. Program concepts were presented through hands-on activities, laboratory experiments, and visual interactive computer models of physical systems. Participants were required to use assessment materials, such as daily computer journals and group concept maps, to evaluate their learning.

During the second week of the program, participants attended morning information sessions and spent afternoons designing and conducting group experiments. They organized their own groups and conducted their own research, presenting their results on the last day of the summer program.

Findings**Network Communications 1994-1997**

Overall about 80% of the participants from the summer program communicated through telecommunications for one or more years. This was determined by examining the frequency of email messages sent to the program staff address, participant postings appearing on the bulletin board, participant receipts from group mailings, and participant attendance at on-line conferences.

Dialogue Regarding Technology and Program Goals

Participants mentioned the topics related to the summer program goals in half of all messages to staff and one another. The summer program goals included introducing participants to interdisciplinary science topics, assessment tools, technology, and to the idea of teachers acting

Telecommunications Supporting Science Teachers

as mentors to students in the classroom (Table 3). The staff established a telecommunications network to provide participants with support to continue using these ideas from the summer program and to sustain their professional development beyond the summer institute.

Comments related to technology from the summer program were most frequently mentioned in this network, as shown in Table 3. For the purposes of this paper, the discussion will focus only on technology-related dialogue. The alternative assessment tools were introduced through the computer; as a result dialogue pertaining to the alternative assessment computer software also will be included in the technology findings.

Table 3

Occurrence of Program Goals Mentioned in the Network

	Science Topics	Technology	Alternative Assessment	Teaching Role
Email n= 916	77	49	13	10
Bulletin Board Postings n= 367	37	61	20	0
Conferences n= 4	20	67	2	1
Totals	134	177	35	11

When participants discussed technology, they either stated their purpose in the context of a technical comment, a resource, or a classroom experience. Teacher participants expressed such dialogue in email, bulletin board sections, and conferences.

Email Dialogue

In email messages, the majority of technology-related dialogue consisted of participant requests for technical advice, which were most common in the fall months following the summer program. For example, one teacher described technical problems with software or hardware:

I am trying the discs with my kids. Those marked one and two don't work . Am I doing some thing wrong or is it the disc? I have divided my class into groups each will focus on one experiment that we did and present to the class. I would like them to be able to use

the programs to do their work. But so far I am stymied. Can I get new discs or will you give instructions so I can use the in I have?

Although second year teachers continued to send technical questions periodically, they were more descriptive with explanations describing how the technology was being used in the classroom,

They were saved as PICT files and then opened in FD 5.1 on my Mac at school. Only scattered dots appeared and when measured had fd's of 1.7 to 1.9, widely scattered and seemingly useless. The images in FD didn't look at all like the saved PICTs as they appeared in Image 1.44. Maria is the student that did the analysis of the galaxies last year. She is a super worker and very meticulous when it comes to her research. Any input is greatly appreciated. She doesn't have a computer at home and can only get e-mail through my account. I'll be checking each day

Technical inquiries comprised 15% more of the technology-related email messages in 1994 than in 1995. The 1994 participants sent three times more technical questions about technology equipment than 1995 participants. Twenty five percent of the 1994 teachers had experience using technology in the classroom as compared to 70% of the 1995 participants. Teachers shared experiences using technology.

Those teachers who shared teaching experiences with technology during their first year of using the program materials mentioned the assessment tools;

Probably the most used piece of software has been the Concept Map. I have used it for all grade levels both as an introduction to material as well as sort of a post-review. It has been wonderful to see the difference between the two.

Teachers usually expressed how they were using this technology in their curriculum when they sent email to program staff. The concept map computer software and learning logs were assessment tools introduced to the teachers and used every day during the summer program. When teachers shared classroom experiences about technology, through email, they mentioned assessment tools, rather than scanners in their first year. Most teachers were trying to determine how to set up a scanner or how to obtain one for the school.

Thirty five percent of the teachers who sent technical questions began to share experiences during their second year of participation in the network:

I also have a student who is working on a computational science project in fractals that we hope to enter in our state EXPO (a computational science competition). His project is on Fractal Analysis of Trabecular Bone as an Indicator of Bone Strength. He is using Fractal Dimension as well as writing a program (in C) that will do determine FD. In addition, my Biology I students have completed the exercises on termites and root growth. We compared FD of the roots of different plants.

In this case, a teacher described how she was having a student use the fractal dimension (FD) software to collect data as part of a student's science fair project and also as part of the classroom. This example required the use of a computer as well as scanning equipment. This teacher asked several technical questions with the software and hardware during her first year of the program. In addition, she like 75% of the teachers mentioned that she used the program materials / technology as an independent project rather than a class activity. Sixty percent of the first year teachers stated that they were unable to find time to integrate new things into their curriculum while others did not have access to technology for whole class activities. Email messages to program staff consisted of technical messages regarding computer simulations, scanners, software, networks and video microscopes. Those teachers who mentioned assessment tools shared experiences about how they were using the technology. During the second year, more teachers described how they integrated technology in their classrooms.

Bulletin Board Dialogue

The majority of postings in the bulletin board sections (64%) consisted of technical comments relating to technology from the summer program. A specific "Technology" section was created by program staff as a means to provide public support for technology. The first message posted by a teacher was typical of those to follow:

I'll start it off for us all... My school and district has a limited budget. It looks like we can maybe get 4 to 6 machines for the program with much groveling and bargaining. We have a scanner, video microscope, and video cameras available, so what is the best and the least we should shoot for? Guess we have all bombarded you with questions and probably made you feel like you were balancing a shopping cart on your chin! ;-)
I do have that price list but you helped me define what I am looking for!

Most teachers posted concerns about managing or setting up technology. However all teachers who posted messages were not seeking program assistance. Often, when some one posted a message, the more computer-literate teachers provided advice as well as program staff,

I have had good luck with using the 1-800-800-APPL number to get apple pricing and information. You can also use their automated information if you have a fax machine. They will fax you a directory of their information sheets, and you can use this to get further information via the fax machine. They will also fax you a current educational discount price list.

This section of the bulletin board became a place for troubleshooting problems and sharing advice or general experiences with software and hardware. Sometimes a teacher would post a message requiring an immediate response:

Help, help. I have a student who is analyzing crystals for a Science Fair Project and we have a major problem....she scanned the crystals, saved them in PICT format and opened them in Fractal Dimension 5.1 only to find the picture is reduced to weird scattered dots. When opened in Image 1.44, they look like the crystals.....but we can't get them in FD to measure the fd for data! What are we doing wrong??? This worked great the other times we did this with galaxies and other patterns.

Usually a message with this urgency was sent to program staff directly through email.

Technical comments about technology occurred most frequently in the fall and winter months.

Messages regarding participant experiences with alternative assessment tools occurred mostly in the later in the school year (winter and spring months).

I started electronic learning logs on the second day of school and have been using it once or twice a week. I've found that groups of 4 do not make a good collaborative group because usually one person sits idly by, unless there's a really hot topic to argue about. I now ask students to respond individually on selected questions (of course they can still get help from their group) but at least this gets them involved. I have 6 computers in the classroom, plus the teacher work station (but we're not networked yet so I have to save everything on disk). Our adjacent computer room is networked so it makes it much easier to load programs.

I use the learning logs in my second year biology class, Bio II: DNA Science. I found that student comments are very helpful. Whenever we do a lab, I ask them to troubleshoot the lab for me since this is the first time that I'm running these labs with a full class. I now have a record of all of the mistakes that they made and good suggestions for improvement and timing of procedures for next year. In terms of students trying to make sense of the material, the logs have been especially helpful in having them elaborate on complicated topics. (this especially works when I have enough time to respond and have them work on the logs the following day to clear up misconceptions). More on this topic later.

This type of dialogue demonstrated a higher level of understanding about program technology, as teachers described how or why the technology worked well for the students and their learning.

The above example was a teacher who practiced in a school system rich with technology. Most teachers felt as the teacher who commented to this message;

Well I envy any of you who have computers right in your classroom! I've been using the Learning Logs with my students and like them very much; the kids do as well, and that's what's important. My only frustration is that, because of computer classes being run in the computer room during biology class periods, my students can only use the computers one day a week. The frustration comes in because it's a full week before they can read what I've written in response to them, and respond to that.

On the positive side, I think they're great. It is so satisfying to watch the kids REALLY involved in collaborating, arguing, thinking... The log works wonderfully with one student in particular who is taking Advanced Biology independently. We each check the log on a daily basis during free (ha ha ha) time. Because of schedule differences, it's really the only way we could communicate on a daily basis.

That's it for now.

She describes how she is dealing with technology shared with other colleagues outside the classroom. She also mentioned the use of technology for independent projects; many teachers sharing experiences during their first year using the materials described their use of technology as an outside project.

Throughout the postings, participants mentioned the barriers that affected them in their schools. For example,

As usual school has started, I've gotten some assignments in and I'm behind in grading! I don't have some of the stories of successfully integrating the PINS stuff in class yet. I'm working on the six computers in my class, trying to get them networked and figure out the sharing stuff etc. Unfortunately the computers belong to the whole science dept. so next week they are off to another teacher's room. I guess one thing that keeps me from integrating too much too soon is just the 100 students I have and the necessity sometimes to NOT change too much just for survival.

This teacher comments on his problems getting started with technology; he used several hands-on laboratory activities that he shared with the others; however, he did not use technology during the first year using the program materials. He does raise another interesting point; he communicated outside the PIN network, with a PIN colleague who gave him some advice on managing things; by the second year, he was integrating scanning equipment into his curriculum. However, he like many teachers, faced the problem of accessibility of technology.

Other program activities, such as alternative assessment tools and science lab activities, were mentioned in messages when participants shared their classroom experiences. Reflections about implementing or planning with alternative assessments were most exclusively reflections about students. Participants shared their thoughts about student outcomes while implementing new materials. Bulletin board sections provided a place for teachers to share experiences, share resources and troubleshoot ideas. The dialogue within the postings was much more reflective or descriptive of the conditions in the work place.

Conference Dialogue

Conferences were organized at least two times a year. On average conferences included 3-5 program staff and 8-13 teachers. Conferences focused on various topics which were proposed collectively with the group. For example, one teacher expressed his frustration having one computer in the classroom. Several other teachers raised these concerns in the bulletin board sections. Program staff asked if he would host a conference to raise this for discussion. The focus of the conference was on using a single computer in the classroom:

- HOST : One of the topics for tonight's conference is how people use PINS materials with just one computer
- P1 : I've used one computer and a TV hookup (CV Link) to do class demos, but can only do short ones
- HOST : Some teachers do not have the luxury of multiple computers and have to get by with one or two.
- Staff 1 : I introduce some topics with one computer by hooking it up to an overhead projector
- HOST : P2 does your TV hookup have a lot of flicker?
- Staff 2 : Do the students get as involved when it is overhead vs. their own?
- P1 : Host, the only program that I have tried so far has been the diffusion chamber and I couldn't get it running. Anybody have any suggestions?
- Staff 1: The period has to be divided up into hands on activities as well as cooperative learning sessions the old overheads get a hot spot that fades out the
- P3 :Host, the TV doesn't flicker much so it does work better than a computer screen but kids don't get involved too much. they can see illustrations of ideas that way, though.
- HOST : I have used an overhead hook-up but it's not as clear as a TV or monitor and it fades out.
- P4 :Have people tried letting students do the demo on the overhead?...
- Staff 3 : When using an overhead you must try to get one of the newer versions with the extra strong fans.
- P4 : Students seem to get more involved when other students are running the show.
- P3: I like the idea of students doing the demo.
- HOST: Another possibility is to develop a variety of lab activities, one of which uses the computer.
- HOST: Then you rotate kids to different activities. By the end of the period they have done everything.
- P3 : Usually when I only have one computer, though, I don't really plan to use it.
- P5 : Great, I just got my only LC 575!
- Staff3 : Several middle school teachers I know use one computer as a part of a multiple lab setup. They plan the work so some students do regular labs while one group uses the computer/then rotate.
- HOST : I have funding (a few thousand dollars) to purchase good science software, in addition to PINS software I could use recommendations for interactive software.
- P4 : I used one to demonstrate the coin toss for genetic probability. Nice.
- P2 : I am still fighting for computer turf, Staff 4 have you sent letters to superintendents yet?
- HOST : A computer is coming to the H.S. in Sept.
- P2 : our computer room is too tight for a full class and I find myself trying to be in two places at once

- Staff 4 : Hmmmm! So guess the real issue is dealing with one computer in the classroom.
- P5 : I have 7 computers in my room and 12 in the adjacent bio computer room. No problems with having one.
- HOST : To summarize: 3 ways to use 1 computer. First is to use a large screen TV or monitor. Second is to use an overhead projector. Third is to use the computer as part of a variety of activities and have kids rotate.
- P3 : The TV links for Mac's are a cheaper way to get color demos than a color LCD panel.
- Staff 4 : I have fears of using the computer as demo device, especially with simulations.
- Staff 5 (just entered)
: My primary concern is that students won't be able to distinguish between simulations and animations. Anyone else have this worry?
- P6 : Definitely, simulations need the students to be able to "play"
- P7 : and TV doesn't require lights out, but may not be big enough for text
- P4 : Peter I think many worry about this...the question is what to do??
- HOST : Staff 5, you're right. But what choice do we have?
- P3 : Staff 5, I agree but if it's all you've got....
- Staff 3 : I agree Staff 5. Simulations don't work unless the operator is in control.
- HOST : I don't think anyone would use only 1 computer if they had many.
- P6 : One computer would work if you have a variety of activities going on so some can be on the computer
- P2 : Students' perceptions of what we do in class is often very different from ours under the best of plans
- P4 : Teacher as facilitator. Some kids doing lab work, computer, text questions.

The script goes on. There are discussions about securing the computer so the student does not get into private information; there is discussion about new equipment, like scanners, teachers are waiting to obtain. And there was additional discussion about software. From this dialogue among staff members and seven participants, there were issues raised about managing the classroom and focusing on the drawbacks and positive aspects for student learning. Several months after this experience, the host did report in his use of the single computer which he integrated as a simple demonstration that became a station for students to work through as they progressed through other activities that day.

In addition to troubleshooting problems together, conferences allowed teachers to catch up socially, share resources about a topic, and follow up from postings in the bulletin board.

Participants-Staff Interactions

Program staff developed a facilitating and collaborative relationship with the groups of participants. Staff created introductory sections for participants to use before meeting at the summer program. Following the program, staff created a "Technology" section within the bulletin board. These initial sections were designed to provide immediate interactions and support. When program staff sent email messages, they encouraged participants to share experiences or concerns by asking questions pertaining to email messages, helping participants with questions, or encouraging them to post messages on the bulletin board or in a newsletter. Staff initiated these types of participation through a separate bulletin board section referred to as 'Weekly Update' a section for staff announcements. Program staff also distributed network surveys three times within the year; this helped to monitor the efficiency of the network and determine what other support teachers preferred.

Participants initiated most (69%) of the messages in the bulletin board sections. Of the messages posted by participants, 30% were responses to other participant's ideas, and 1% were responses to staff-posted messages. Any email messages sent to the staff address received a response within two days. Any message that required forwarding to technical staff was followed-up to the participant. In addition, participants with problems or questions, such as technical problems with the AOL network software, would receive a private response followed by a public proposal from staff indicating to the group the "recent need for" information about the network.

Staff initiated activities but maintained a facilitating authority encouraging teachers and finding ways to support them through the network. On-line surveys indicated that participants were pleased with the efficiency of support and responses from program staff.

Evidence of Professional Changes

Participants demonstrated interests in technology in several ways within this network. Program staff also encouraged several types of activities within the community. Teacher participants demonstrated changes from their first days of participating in the summer program to their two or three years interacting with colleagues. For example, as indicated previously, some teachers claimed that they did not have direct access to computers and in 5 cases, teachers took action; some sought program staff and others for advice or grant writing for technology and others became more involved in school committee work:

The Pins experience has been helpful to me, particularly since I joined on the school district's long range technology planning committee. I asked for the technology to capture

and scan patterns for the graphical analysis program. Also we are requesting networkable work stations similar to the ones that we used in Boston.

In two cases, teachers sent email to staff indicating that they had received some funding so that they could carry out these types of projects.

When staff disseminated email surveys, they asked participants for suggestions on expanding the network to meet their needs, which led to an increase of the participant-created sections within the bulletin board. One teacher participant created a section for discussions about concept mapping and other teachers requested a staff member to establish a section about learning logs. These two sections led teachers to share their experiences about program activities. Another teacher created a section about a technology topic not related to the program, which led to the development of a new interest and a separate discussion group. Participants created and introduced the group to new professional interests within the community. They also created additional ways for teaching to grow.

Participants mentioned teaching practices as they described how or why they evaluated, planned, and implemented their lessons with technology. Descriptions of how or why participants performed a lesson were examples of reflections about practice. An analysis of reflective dialogue indicated that participants reflected about how to manage technology in the classroom and later reflected about how the technology worked for the students after 2-3 years of experience with program materials.

Participants also indicated how this experience changed their practices "...browsing the bulletin board sections and talking to others via email showed me how to integrate the information from the summer program." One teacher felt he became "part of a global group of professionals." Another participant indicated that with the support for using and maintaining technology, he felt comfortable to take a leadership position on "internet-based activities" for his local school committee. All participants indicated that this opportunity was necessary for communicating with teachers to share effective activities and methodologies to prepare students; this opportunity provided an easy way to contact professionals that could enhance teaching.

At the end of the program, teachers were given a survey to describe their experiences with the program and telecommunications. All participants listed and explained that the most important aspect of this program was the telecommunications network because they gained moral support from one another, shared activities, experiences and gained teaching support. The participants were also asked what aspects of their teaching, classroom changes, and relationships with students had changed. Teacher participants who had been interacting for two and three years

indicated that technology impacted one or more of these aspects of their professional life. In the classroom, teachers claimed that they were more reliant on computers-based activities, more comfortable using different technologies in the classroom, and integrating technology into activities. In one case a teacher mentioned that his relationship with students changed as he began to see that the students are the computer experts and he was a facilitator.

Teachers who had implemented program materials for one year stated that they could not answer this question because they could not see changes at this time. Some of these teachers indicated that they felt more involved in teaching because they had an opportunity to share ideas with others. This was consistent in all the surveys from this group.

Teachers also claimed that using technology changed their teaching style. Three teachers mentioned feeling more confident with technology and were thinking of ways to utilize it in teaching regular lessons. One teacher mentioned that telecommunications had become part of his constructivist philosophy. For other teachers, learning about telecommunications was their introduction to the world wide web. Another teacher mentioned that he was able to integrate more types of media in teaching; such as computer presentations and the Internet. And one teacher claimed that she was now able to instruct technology workshops in her district.

Teachers who had interacted within the network for two or more years described how technology affected them in the classroom, with students, and personally in their teaching style. Technology from the PIN program affected teaching and learning in various ways.

Conclusion and Implications

Teachers communicated in different ways through email to staff, public bulletin board sections, and conferences. The summer program introduced science teachers to an interdisciplinary approach to science. Technology was a large component of the program and required the most support for teachers. Participants sought technical assistance directly with staff through email, while discussing management issues, troubleshooting ideas, sharing resources, and sharing experiences in the public areas of the bulletin board and at conferences.

Teachers demonstrated professional development by expressing their interests, sharing their experiences and resources, and reflecting on the ways they used or planned to use technology in the classroom. In addition, teachers demonstrated change as they took initiatives to search for funds to implement technology in their schools, and they conducted activities like conferences and bulletin board sections to share experiences with technology.

Accessibility, resources for equipment, and time remain barriers teachers face as they try to implement technology in their classrooms. Telecommunications serves partly as a tool for observing the problems and situations facing teachers and yet it also established into a collegial environment empowering teacher participants to act on problems. In addition, opportunities like bulletin boards and conferences give teachers experiences to troubleshoot and perhaps overcome some of these problems with colleagues.

This type of collegial context revealed certain aspects of professional development consistent with current models for professional development and strategic reform (Guskey, 1986; McLaughlin and Talbert, 1993; Mevarech, 1995). For example, teachers demonstrated that it takes time for changes in teaching. One year after working with materials from the summer program, teachers could not recognize changes in their teaching, relationships with students or changes that had taken place in the classroom. Even in teacher dialogue, many teachers could not share experiences until their second year of using the program materials.

The goal of this research study was to determine what type of professional support could be sustained within a telecommunications network. Given the general structures (email, bulletin boards, and conferences) and the facilitating leadership of program staff, a community of teachers were able to gain support from a program and one another, share experiences, and reflect about new teaching experiences. A telecommunications network can provide an additional supportive environment for teachers implementing technology in an environment that is not limited by traditional geographic barriers and time constraints.

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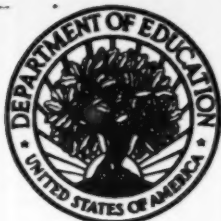
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